



having a projection that fits into the recess of the first component so that an unrestricted tilt-and-turn movement is achieved between the first component and the second component.

[0007] Furthermore, DE 100 24 922 C1, EP 10 41 945 A1, WO 02/080818 A1, U.S. Pat. No. 6,368,350, DE 42 13 771 C1, EP 05 60 140 B1, EP 13 44 508 A1, EP 13 44 507 A1, DE 42 08 115 A1, EP 12 87 795 A1, DE 102 42 329 A1 and DE 197 10 392 C1 also disclose other spinal disk prostheses.

[0008] A drawback of all of the artificial intervertebral disks known so far is that the natural joint properties can only be insufficiently replicated. The patient clearly perceives this restriction of the natural range of motion as causing discomfort when several vertebral bodies have been replaced, as a result of which the disadvantageous properties of the intervertebral disks multiply.

[0009] The invention is based on the object of considerably improving the properties of an artificial intervertebral disk that are perceptible to the patient.

[0010] This object is achieved according to the invention with an artificial intervertebral disk according to the features of claim 1. The subordinate claims relate to particularly advantageous refinements of the invention.

[0011] Consequently, according to the invention, an artificial intervertebral disk is provided wherein the two elements have a contour by means of which the elements are positively joined to the intermediate element. The invention is based on the notion that the desired range of motion can replicate the natural range of motion of the vertebral column in an optimal manner using an artificial intervertebral disk if the intermediate element is held positively in a corresponding contour of the element, since this means that torsional moments as well as shear forces can be transmitted without any problem and without having to forgo good deformation properties of the intervertebral disk. As a result, the intervertebral disk can be configured especially so that, at the same time, the

relative mobility of the elements with respect to each other, that is to say, especially a tilting movement, can be greatly optimized, i.e. the mobility can be improved. In other words, when the function of the transmission of torsional moments and shear forces between adjacent vertebral bodies is uncoupled from the function of the articulated connection of the elements that are associated with the vertebral bodies – the latter function being uniformly achieved according to the state of the art by the elastic properties of the intermediate element in an inadequate manner as a compromise among the various properties – this uncoupling results in essentially divergent degrees of freedom corresponding to the optimum in each case. Thus, according to the invention, it is possible to join adjacent vertebral bodies in such an articulated manner that mechanical properties are attained that are similar to those of the natural intervertebral disk.

[0012] An especially advantageous embodiment of the vertebral disk according to the invention is achieved in that the contour is concave, thereby forming, for example, a recess for positively receiving the intermediate element. The contact surfaces are configured here in such a way that, in any case, the cohesive friction cannot be overcome by the shear and torsional load.

[0013] In actual practice, it has proven to be especially promising for the contour to have a friction-optimized surface texture, since as a result, any possible abrasion of the material of the intermediate element can be reduced or prevented in a simple manner. For example, in the contact area, the surfaces of the contour are polished with a specular finish in the contact area so that, when relative movements occur at the contact surfaces, the friction and thus also the abrasion on the intermediate element is minimal.

[0014] In contrast, another likewise practical modification is achieved if the contour has a surface texture or roughness that increases the friction, at least in sections, in order to create a non-positive connection between the two elements and the intermediate element. In this manner, a design of the contact surfaces is achieved with which, in any case, the cohesive friction is not overcome by the shear and torsional load.

[0015] Moreover, it has proven to be especially practical for the contour to be configured with such an oversize with respect to the intermediate element that a compression of the intermediate element stemming especially from movement by the patient allows a defined deformation. Here, the surface curvature causes the contour to be dimensioned slightly smaller in comparison to the cross sectional surface of the intermediate element, so that the deformation of the intermediate element, which is, for example, annular, that occurs in response to compression allows its expansion parallel to the plane of the elements.

[0016] The intermediate element could be configured as a disk whose edge area has beads that engage in the correspondingly shaped contour. In contrast, an especially promising configuration is achieved if the intermediate element has an annular closed shape. In this manner, the torsional moments and shear forces that occur during movement can be transmitted in an optimal manner and, in addition to circular intermediate elements, it is also suitable to use oval or kidney-shaped intermediate elements since these already allow a positive transmission of torsional moments due to their basic shape, which diverges from the circular shape.

[0017] According to another likewise especially advantageous variant, the annular intermediate element has an ogival, oval or circular cross sectional surface crosswise to its annular central axis, at least in sections, so as to concurrently ensure an optimal force transmission between the elements and to concurrently achieve the desired mobility. Here, the corresponding contour, at least in sections, is shaped accordingly, especially as a function of the different body planes.

[0018] Moreover, it has proven to be especially advantageous for the intermediate element to have a cross sectional surface that differs in sections in the direction of its annular central axis and that interacts with a correspondingly shaped contour so that a positive connection between the intermediate element and the outer elements allows torsional moments to take place. For example, constrictions can be provided in sections for this purpose. The diameter of the ring cross sectional surface can be modulated along

the ring so that, even in the case of a ring that has a circular shape as seen from above, a rotational movement of the ring between the plate-shaped outer elements can be ruled out.

[0019] For example, for this purpose, the cross sectional surface in the sagittal plane, in the frontal plane and/or in the transversal plane of the patient can be widened in sections.

[0020] Fundamentally, the material properties can be selected as a function of the particular requirements. In actual practice, an especially advantageous configuration is one in which the intermediate element is made, at least in sections, of a polymer, especially polyethylene, so that it has very little susceptibility to wear while concurrently having high toughness and a limited elastic deformability.

[0021] Moreover, an especially reliable connection of the intervertebral disk will provide the elements with anchoring pins or anchoring elements that serve for anchoring in the bone on the sides facing the vertebral bodies and, during the implantation, these elements anchor themselves into the vertebral bodies.

[0022] Here, in an advantageous manner, the elements with their anchoring pins or anchoring elements are coated with titanium or other biocompatible materials on their side facing the vertebral bodies, these materials allowing a direct connection to the bone.

[0023] The invention allows various embodiments. In order to further elucidate the basic principle, one of them is shown in the drawing and will be described below. The drawing shows the following:

[0024] Figure 1 a sectional side view of an artificial intervertebral disk according to the invention;

[0025] Figure 2 a top view of various intermediate elements for an artificial intervertebral disk according to the invention;

[0026] Figure 3 various cross sectional shapes of the intermediate elements shown in Figure 2;

[0027] Figure 4 merely a section of an enlarged side view of an intermediate element shown in Figure 2;

[0028] Figure 5 another artificial intervertebral disk according to the invention in a sectional side view;

[0029] Figure 6 the arrangement of the artificial intervertebral disk shown in Figure 1 between two vertebral bodies of a vertebral column.

[0030] Figure 1 shows a sectional side view of an artificial intervertebral disk 1 according to the invention, by means of which two adjacent vertebral bodies (not shown here) of a patient are joined to each other in an articulated manner. The artificial intervertebral disk 1 has an intermediate element 2 configured as an elastic ring that is inserted into a contour 3 of two outer elements 4 that are made, for example, of metal plates. The outer elements 4 are joined to the bones of the vertebral bodies by means of anchoring pins 5, especially titanium anchors, which are generally known from the field of hip prostheses. The radius D of the concave contour 3 has an oversize with respect to the diameter d of a circular cross sectional surface of the intermediate element 2, so that a compression of the intermediate element 2 stemming especially from movement by the patient allows a defined deformation.

[0031] Figure 2 shows a top view of various possible shapes of the intermediate element 2 of the artificial intervertebral disk 1 according to the invention and each of these intermediate elements 2 has an annular closed basic shape. Shown by way of an example are intermediate elements 2a, 2b, 2c with a circular, oval or kidney-shaped basic

shape. By the same token, of course, these basic shapes can also be provided with intermediate elements without cutouts (not shown here).

**[0032]** Figure 3 shows by way of an example various cross sectional shapes of the intermediate element 2, which can be oval, circular or ogival on both sides. In the direction of the annular central axis 7 of the intermediate element 2 shown in Figure 4, the cross sectional shape can also be configured differently in sections and can vary, for example, between the different cross sectional shapes depicted.

**[0033]** Such a varying cross sectional shape is depicted in greater detail in Figure 4, which shows an enlarged side view of an intermediate element 2 shown in Figure 2. One can see regular constrictions 6 of the circular cross sectional shape in the direction of the annular central axis 7 of the intermediate element 2 through which the occurring torsional moments can be transmitted due to a positive connection of the intermediate element 2 to the outer elements 4 shown in Figure 1.

**[0034]** An embodiment of another artificial intervertebral disk 8 according to the invention that differs from that of Figure 1 is shown in a sectional side view in Figure 5. The intervertebral disk 8 has outer elements 9 configured as perforated plates having a central cutout 10 so as to improve the integration of the vertebral bodies 11 depicted in Figure 6.

**[0035]** Figure 6 shows an arrangement of the artificial intervertebral disk 1 shown in Figure 1 between two vertebral bodies 11 of a vertebral column (not shown here). For purposes of anchoring in the vertebral bodies 11, the outsides of the intervertebral disk 1 facing the vertebral bodies 11 are provided with anchoring pins 5 that, during the implantation, anchor themselves in the vertebral bodies 11. A biocompatible coating on the sides facing the vertebral bodies 11 allows a direct connection to the bone.